



University of
Miami

In Situ Chelation/Reduction Process for Remediation of Subsurface Metals and Radionuclides

Technology Need:

Metal and radionuclide-contaminated groundwater and soil are a problem at many former Department of Energy (DOE) nuclear weapons facilities, and radionuclides can be a problem even in parts-per-trillion concentrations. Cost-effective means are required to minimize the migration of these toxic metals and radionuclides into previously clean areas or their leaching into groundwater systems that can spread the contamination. These contaminants have, in many cases, migrated horizontally and vertically to contaminate large areas of the aquifers underlying these sites. Contamination may extend to hundreds of feet beneath the surface. The baseline method for treatment of contaminated soil invariably employs ex situ technology, which is both expensive and fraught with safety challenges during excavation and handling. Also, pump and treat systems are often projected to require as much as 200 years to achieve treatment objectives. Competing in situ technologies under development have proven so far to be either extremely difficult for large-scale in situ subsurface stabilization, incapable of reducing some metals, and radionuclides, such as arsenic, or are excessively high in cost.

Technology Description:

The University of Miami is developing an in situ process for removing hazardous metals, radionuclides, and organics from groundwater and soils. In this process, circulation is induced in the groundwater by means such as injection/extraction wells, or by a circulation well (also known as recirculation wells, or in-well vapor stripping processes). During the extraction phase of the circulation, a chelating agent is added to the water. The chelating agent binds any of a broad range of divalent and trivalent metal ions and atoms in the soil and groundwater, so that metal contaminants are transported with the water.

Circulation is continued until the chelating agent, ethylenediaminetetraacetic acid (EDTA), is saturated with metal contaminants and contaminants are reduced to the desired level in the soil. Following this extraction phase, a natural, passive reactant and air are added to (a) destroy the chelating agent, and (b) remove the metals from the water. Contrary to expectation, laboratory results have shown that this inexpensive reactant/catalyst, together with aeration, actually decomposes the EDTA molecule, releasing and co-precipitating the metal. Evidence in the literature suggests that the reaction is a conversion of the diamine tetraacetic acid group to glycine, acetic acid, and simpler organics, with consequent elimination of the chelating ability of the EDTA and no anticipated environmental impacts. Following EDTA reduction, the metal contaminant is precipitated onto the reactant for removal from the well. A trace amount of natural reactant replaces the trace metal ions in the water.

The proposed process makes the use of EDTA economical, although cost has discouraged its use previously. In the proposed process, the groundwater is circulated until the chelating agent is saturated with metal contaminant. Metal cations of concern are preferentially bound by the chelating agent, relative to calcium, magnesium, aluminum, and iron found geologically. While some chelation sites may be initially occupied by competing metal ions such as calcium, during the course of recirculation these competing ions will be replaced by any remaining hazardous metal ions. Thus, the recirculation aspect of the process will reduce chemical costs substantially. In addition, metallic anions such as arsenate and chromate will be dissolved and transported to the well, for removal by co-precipitation. Finally, although the proposed process is intended to clean up metals and radionuclides in the subsurface, the process is likely to remove volatile and biodegradable organics simultaneously. For

example, if the process is implemented as an enhancement of the recirculation-well process, such organics are expected to be removed by stripping into the injected airstream, and by biodegradation in the presence of elevated dissolved oxygen concentrations.

Benefits:

- ▶ Costs of the proposed process are projected to be 10% or less of those of currently available technologies.
- ▶ Cleanup time using the proposed process may be measured in weeks or months rather than years.
- ▶ Residues would be orders of magnitude less than for excavation.

Status and Accomplishments:

Laboratory column studies were conducted to demonstrate the passive reduction of the chelating agent and metal contaminants. Chemical byproducts were identified using chromatographic and other techniques. Results show that the process successfully treated most metals of interest to below detection limits. Several DOE sites have shown interest in the process.

On DOE approval to proceed, bench pilot tests will be conducted to determine the efficiency of removal of nickel, cadmium, lead, mercury, arsenic, vanadium, and chromium, at different EDTA concentrations, dissolved oxygen levels, recirculation cycle lengths, with and without addition of ultrasonic energy, and to identify chemical byproducts of the proposed process.

Finally, on DOE approval, a full-scale laboratory pilot plant will be constructed and full-scale laboratory pilot tests will be conducted to determine flow rates, hydraulics, process control parameters for different soil types, radius of influence, and the relationship between geological characteristics and process efficiency. Environmental benefits and costs, clean-up costs, and life-cycle costs for cleanup of sites, with emphasis on sites identified by DOE end users, will be developed. Costs for simultaneous cleanup of organics in mixtures

with metals and radionuclides also will be estimated. Plans for a subsequent field demonstration(s) at DOE end-user sites, including infrastructure plans, will be developed.

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Online Resources:

Office of Science and Technology, Technology Management System (TMS), Tech ID # 3174
<http://ost.em.doe.gov/tms>

The National Energy Technology Laboratory Internet address is <http://www.netl.doe.gov>